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2017-04

Ekstam , U , Korhonen , J , Linnanmäki , K & Aunio , P 2017 , ' Special education pre-service teachers' interest, subject knowledge, and teacher efficacy beliefs in mathematics ' , Teaching and Teacher Education , vol. 63 , pp. 338-345 . <https://doi.org/10.1016/j.tate.2017.01.009>

<http://hdl.handle.net/10138/310833>

<https://doi.org/10.1016/j.tate.2017.01.009>

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TEACHER EFFICACY BELIEFS IN MATHEMATICS

Ekstam, U., Korhonen, J., Linnamäki, K. & Aunio, P. (2017) Special education pre-service teachers' interest, subject knowledge, and teacher efficacy beliefs in mathematics. *Teaching and Teacher Education*, 63, 338-345.

Abstract

Teacher efficacy beliefs is an important characteristic to predict instructional quality and the level of cognitive activation and educational support. Since teacher efficacy beliefs are context and domain specific, this study focuses on how special education pre-service teachers' individual interest and subject knowledge in mathematics predict their efficacy beliefs in teaching mathematics. Data were collected from 57 special education pre-service teachers. The results indicated that the individual interest of pre-service teachers has a strong effect on teacher efficacy beliefs, while subject knowledge has only an indirect effect.

Keywords: teacher efficacy beliefs, mathematics, motivational beliefs, pre-service teachers, special education

Special education pre-service teachers' interest, subject knowledge, and teacher efficacy beliefs in mathematics

Research has clearly shown that quality teaching is of importance to student achievement (Bolyard & Moyer-Packenham, 2008; Brownell, Sindelar, Kiely, & Danielson, 2010; Clotfelter, Ladd, & Vigdor, 2007; Kunter et al., 2015) and the teacher has been identified as the most important school-related factor determining student performance (Hattie, 2009; McCaffrey, Lockwood, Koretz, & Hamilton, 2003; Rowan, Correnti, & Miller, 2002), particularly for students in need of support (Levi, Einav, Raskind, Ziv, & Margalit, 2013). It has also been found that the effect of teachers on student achievement is stronger in mathematics than in reading, for students in low socioeconomic areas (Nye, Konstantopoulos, & Hedges, 2004), and for higher grades (Jepsen, 2005). In addition, it is reported that teacher effects on student learning are cumulative and long-lasting (Heck, 2009).

Traditionally, teacher characteristics have been measured on the basis of subject knowledge, certification and experience; however, in the past decade, research has also acknowledged the importance of teachers' attitudes and teaching beliefs in student performance (Bong & Skaalvik, 2003; Bursal, 2010; Evans, 2011; Gresham, 2008; Kim, Sihn, & Mitchel, 2014; Swars, 2015; Swars, Hart, Smith, Smith & Tolar, 2007; Swars, Smith, Smith, & Hart, 2009; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998; Woodcock & Reupert, 2016). Hattie (2015) for example, noted in his meta-analysis that collective teacher efficacy has one of the largest effects on student performance. Consequently, it is important to investigate which factors contribute in shaping these beliefs (Austin, 2013; Kleinsasser, 2014). Previous research have shown that teacher's interest (Long & Woolfolk Hoy, 2006)

and subject knowledge (Boylard & Moyer-Packenham, 2008; Coltfelter et al., 2007; Feng & Sass, 2013) predict teaching efficacy beliefs. However, studies focusing on subject knowledge and efficacy beliefs have not controlled for the possible confounding effects of interest and vice-versa. Thus, knowledge on the mutual relationships among teachers' efficacy beliefs, interest, and subject knowledge can increase our understanding of how pre-service special education teachers can be supported in developing their competencies and beliefs about themselves. Teacher efficacy beliefs are context specific, that is, they have meaning only in specific learning environments (Austin, 2013; Siwatu, 2011; Tschannen-Moran et al., 1998). However, most research on the topic refers to general pre- and in-teachers and few studies address teacher efficacy beliefs in the area of special education and mathematics. As an addition to the literature, this study aims to investigate if and how pre-service teachers' subject knowledge and interest in mathematics have an impact on teacher efficacy beliefs. Implications for teacher education will also be discussed.

Basic competence in mathematics has become increasingly important in managing day-to-day activities. Therefore, it is necessary to identify and remediate students with low achievements in mathematics (Geary, Hoard, Nugent, & Bailey, 2012). According to the Programme for International Student Assessment (PISA) 2012 results, about one in four students in OECD countries reported less than proficient levels in mathematics (Organisation for Economic Co-operation and Development [OECD], 2016). Poor school performance affects not only the individual but also the society and even the national economy in the long run (European Commission, 2013). Low performance is a consequence and accumulation of several factors and disadvantages (e.g., socioeconomic status, single parent family, and immigrant background). Students with low performance tend to be less motivated and skip more classes than better-performing ones and have low self-confidence in mathematics (OECD, 2016). Measures to reduce the incidence of low-performing students include

identifying low performers and designing a tailored strategy to provide early remedial support, create supportive learning environments and inspire and motivate students to make the most of education opportunities (OECD, 2016). To fulfil these actions in the context of special education, teachers and especially special education teachers play an important role.

Teaching mathematics to low-performing students can be challenging and requires both in-depth subject knowledge and a strong pedagogical foundation (van Garderen, Thomas, Stormont, & Lembke, 2013). In many countries, special education teachers are certified for grades K12; however, special education programmes primarily focus on the content for grades 1–6, and thus, teachers must deal with a wide range of topics on a level they are not necessarily familiar with. This is particularly true in the case of mathematics (Faulker & Cain, 2013; Rosas & Campbell, 2010). Special education teachers are expected to have an interest in and knowledge on how to teach mathematical concepts and rules and discuss and model mathematical reasoning, which is especially important for low-performing students (Boyd & Bargerhuff, 2010; Mevarech & Kramarski, 2014; Neild, Farley-Ripple, & Byrnes, 2009). In practice, it will depend on special education teachers' own math skills and interest and how well they can teach mathematics for higher grades. Thus, this study aims to investigate how pre-service teachers' efficacy beliefs in teaching mathematics are affected by their interest and subject knowledge in mathematics.

Conceptual and Theoretical Framework

Self-Efficacy

The origin of self-efficacy lies in social cognitive theory and it refers to a person's subjective perception of his or her capability to achieve a preferred outcome in a specific context (Bandura, 1977). Self-efficacy beliefs are formed through experiences and account for what individuals believe they can do with their existing skills rather than the actual skill itself

(Bandura, 1977; Bong & Skaalvik, 2003). Bandura (1994) argues that people's beliefs in their efficacy are developed through four main sources of influence: mastery experience, physiological factors, vicarious experiences and social persuasion. The most important factor contributing to an increase in self-efficacy is the experience of mastery: success raises self-efficacy, while failure lowers it. Vicarious experience is seeing people similar to oneself successfully manage tasks, while social persuasion generally manifests as direct encouragement or discouragement from another person. The effect of physiological factors is more related to one's belief in implications for physiological responses (e.g., shakes, pains, fatigue, and fear) in a specific situation rather than the physiological response itself (Bandura, 1994). Self-efficacy beliefs are also reported to influence thought processes and emotions that affect an individual's motivation and are noted to be skill-, task-, and domain-specific (Bandura, 1997). People with high beliefs in their capabilities approach difficult tasks as challenges to be mastered rather than threats to be avoided; such an efficacious approach fosters deep interest and involvement in activities (Bandura, 1994).

Teacher efficacy beliefs (i.e., teacher self-efficacy) can be defined as a teacher's beliefs and perceptions about their ability to teach students with varying needs and qualifications (Tschannen-Moran et al., 1998) and bring about desired student engagement and learning outcomes (Bandura, 1977, 1997; Skaalvik & Skaalvik, 2007). It is also connected to a teacher's capability to organize and execute teaching tasks in specific contexts (Skaalvik & Skaalvik, 2007). Tschannen-Moran and her colleagues (1998) introduced a conceptual foundation where teacher efficacy beliefs are based on a two-dimensional model, 'teaching task and its context' and 'self-perception of teaching competence' (p.228). Later Skaalvik & Skaalvik (2007) argue that teacher efficacy beliefs are even more complex and measurements have to be adapted to today's standards, with a focus on inclusiveness and the student-centred context we have in schools today. Teacher efficacy beliefs are also noted to vary between

contexts as well as over time (Tschannen-Moran et al., 1998), but there are arguments that it is important for pre-service teachers and novice teachers to establish high teacher efficacy beliefs at an early stage because once established, teacher efficacy beliefs may be hard to change (Bandura, 1997).

Teacher efficacy beliefs are related to teaching strategies, instruction, and motivation (Holzberger et al., 2013; Midgley, Feldlaufer, & Eccles, 1989; Thoonen, Slegers, Peetsma, & Oort, 2011) as well as student achievement (Austin, 2013). Holtzberger and her colleagues (2013) found a strong positive relationship between teachers' efficacy beliefs and instructional quality as well as educational learning support. Teachers with high efficacy beliefs also tend to provide more student-centred instruction; invest more effort into implementing new teaching methods, strategies and personalised learning support (Holzberger et al., 2013); and demonstrate greater flexibility in classroom engagement and lesson design (Temiz & Topeu, 2013). All these factors contribute to student achievement, and are especially important for students in need of support. As a consequence, high teacher efficacy is of great importance for students in need of support (Woodcock & Reupert, 2016). In addition, teacher efficacy beliefs are positively correlated with higher task- and situation-specific mastery experiences (Malmberg, Hagger, & Webster, 2014 work (King-Sears & Baker, 2014).

Mathematics teaching efficacy is a teacher's belief in his or her ability to teach mathematics effectively (Enochs, Smith, & Huinker, 2000). Mathematics teaching efficacy is a significant predictor of teachers' instructional strategies for mathematics, and those with high mathematics teaching efficacy have been shown to be more effective in teaching the subject (Enochs et al., 2000; Gresham, 2008; Swars, 2005). Efficacy beliefs in teaching mathematics are formed through one's mathematics and teaching experiences in instruction (Kim et al., 2014). In addition, teachers' mathematics performance (Newton, Evans, Leonard,

& Eastburn, 2012) and their mathematics self-efficacy are positively correlated with mathematics teaching efficacy (Bates, Lathan, & Kim, 2011; Newton, et al., 2012; Swackhamer, Koeller, Basile, & Kimbrough, 2009). As a result, if a teacher has high a mathematics teaching efficacy, he or she is likely to be more deeply involved in student instruction and classroom engagement as well as implementing new teaching methods and strategies (Bates et al., 2011; Swackhamer et al., 2009; Takahashi, 2011; Temiz & Topeu, 2013). Since student achievement is affected by teachers' instruction and motivation (Hattie, 2009), high teaching efficacy in mathematics can have an indirect positive effect on student achievement in mathematics.

Interest

The concept of interest has been defined as a psychological state that occurs during interactions between persons and their objects of interest (Hidi, 2006). A distinction is also made between situational and individual interest (Hidi & Renninger, 2006; Renninger, 2009; Renninger, Ewen, & Lasher, 2002; Renninger & Hidi, 2011). *Situational interest* is environmentally triggered and described as a transient state involving affective reactions and focused attention (Hidi, 2006; Renninger & Hidi, 2002). *Individual interest*, on the other hand, is a more stable relationship between the person and certain content or domain (e.g. mathematics) and can be described as the attitudes, expectations, and values that he or she identifies with (Krapp, 2002). It is well known that interest has an effect on student learning and motivation (see Krapp, 2002; Long & Woolfolk Hoy, 2006), although interest as a single factor is not enough to succeed; at least a basic level of content knowledge is necessary to make progress (Linnenbrink-Garcia, Pugh, Koskey, & Stewart, 2012). As interest is a cognitive and affective motivational variable, learners' perceived experience with an object or content can develop interest in both positive and negative ways (Renninger, 2009). The deepening of individual interest is said to be linked with the desire to increase one's

knowledge in and engagements with objects of interest as well as feelings of enjoyment, competence, and personal value (Renninger & Hidi, 2011; Renninger et al., 2002).

In this study, interest refers to teachers' individual interest in mathematics. There is limited research on the topic, despite the impact of teachers' interest and beliefs towards mathematics on their instructions and, subsequently, the formation of their students' beliefs, interests, and attitudes towards learning math (Charalambos, Philippou, & Kriakides, 2002; Karp, 1992; Kunter et al., 2008; Long & Woolfolk Hoy, 2006).

Subject Knowledge in Mathematics

Several studies have reported that teachers' subject knowledge positively affects student achievement, especially in mathematics and those in middle and high school (Baumert et al., 2010; Boylard & Moyer-Packenham, 2008; Coltfelter et al., 2007; Feng & Sass, 2013; Hill, 2007; Kukla-Acevedo, 2007; Telese, 2012). Strong mathematical knowledge allows teachers to spend more time and focus on questioning, discussing, and reasoning mathematical processes (Griffin, Jitendra, & League, 2009; Jurik, Gröschner, & Seidel, 2014).

Low-achieving students in mathematics often lack basic skills, and therefore, teachers' subject knowledge and competence in using and explaining mathematical concepts and rules is crucial (Boyd & Bargerhuff, 2009; Mevarech & Kramarski, 2014; Neild et al., 2009). Moreover, since such students tend to be more passive in the classroom, teachers' awareness of relevant mathematical questioning and student-centred classroom activities is important to encourage student participation in mathematical discussions (Griffin et al., 2009). Maccini and Gagnon (2006) reported that teachers' familiarity with mathematical content could also help predict various instructional practices for low-performing secondary students in mathematics.

Effect of Interest and Subject Knowledge in Mathematics on Teacher Efficacy Beliefs

A number of studies have focused on the complexity of factors affecting teacher efficacy beliefs (e.g., Clotfelter et al., 2007; Holzberger et al., 2013; Kleinsasser, 2014), but there is still a lack of understanding on how the factors are interrelated and on the contextual aspects of teacher efficacy beliefs (Austin, 2013; Berg & Smith, 2016).

Subject knowledge in mathematics seems to be connected to teacher efficacy (Bates, Lathan, & Kim, 2011; Newton, et al., 2012; Swackhamer et al., 2009). This is contradictory to studies that find no correlation between subject knowledge and teacher efficacy beliefs (Swars et al, 2007). Teachers' individual interest in mathematics is also found to be associated with self-concept, self-efficacy, and content knowledge (Long & Woolfolk Hoy, 2006). However, Tella (2008) did not find any relation between teacher interest and teacher efficacy beliefs even if both variables affected student achievement. King-Sears and Baker (2014) stated that teachers working with low-achieving students benefit from having high self-beliefs, as it helps teachers maintain interest, motivation, and belief towards their own work.

As the deepening of individual interest is said to be linked with the desire to increase one's knowledge in and engagements with objects of interest as well as feelings of enjoyment and competence (Renninger & Hidi, 2011; Renninger et al., 2002), it can be expected that both subject knowledge as well as individual interest are interrelated and have an impact on teacher efficacy beliefs.

Present Study

Teacher efficacy beliefs are important characteristics that predict instructional quality, level of cognitive activation, and educational support (Holzberger et al., 2013; Midgley et al., 1989; Schiefele, Streblow, & Retelsdorf, 2013; Thoonen et al., 2011). This study, investigated how subject knowledge and individual interest predict the mathematics efficacy beliefs of special education pre-service teachers. As noted by Bandura (1997), and later by Woolfolk Hoy and Spero (2004), efficacy beliefs are easily established in early stages of teacher

training. In addition, perceived pre-service preparation is said to be strongly predictive of teachers' sense of efficacy, thus playing an important role in the development of teacher efficacy with a focus on mathematics (Brownell & Pajares, 1999). To the best of our knowledge, no previous study has investigated the joint effect of pre-service teachers' individual interest and subject knowledge in mathematics on efficacy beliefs.

This study aims to investigate how special education pre-service teachers' efficacy beliefs regarding teaching mathematics is predicted by their interest and subject knowledge in mathematics. In addition, we analyse the mathematical level of special education pre-service teachers.

We pose the following research questions:

1. Does pre-service teachers' subject knowledge in mathematics explain variance in efficacy beliefs?
2. Does pre-service teachers' individual interest in mathematics explain variance in efficacy beliefs?
3. Is there a difference in special education pre-service teachers' level of teacher efficacy beliefs according to instruction and the adaptation of instructions to individual needs and student motivation?

Methods

Participants

The participants comprise 57 special education pre-service teachers studying between years one and five¹ (26.3%, 14.0%, 22.8%, 24.6%, and 12.3%, respectively) in a Swedish-

¹ In Finland, a certified special education teacher has a master's degree with either a major in special education or a major in another subject with a complementary minor in special education (including practice). Approximately, it takes five years to be certified as a special education teacher.

speaking university² in Finland (52 female). This covers about 81% of all active (present and non-working) special education pre-service teachers for the semester. The pre-service teachers participated voluntarily during class and were supervised by authors.

Procedure and Measure

To measure individual interest and self-efficacy, the pre-service teachers answered an online questionnaire, comprising seven items measuring their individual interest in mathematics and 12 items based on teacher efficacy beliefs regarding mathematics. *Individual interest* in mathematics was measured with 7 items (e.g., *'I am interested in mathematics.'*) translated and adapted from validated scales used by Frenzel and colleagues (Frenzel, Goetz, Pekrun, & Watt, 2010) and Trautwein and colleagues (Trautwein, Ludtke, Marsh, Köller, & Baumert, 2006). Pre-service teachers rated the items using a 7-point Likert-type scale (1 = *not at all* and 7 = *very much*). The individual interest scale was piloted on 30 pre-service teachers and Cronbach's alpha for the piloted study was .90.

Teacher efficacy beliefs were measured using the Norwegian Teacher Self-Efficacy Scale (NTSES) (Skaalvik & Skaalvik, 2007). The original scale consists of 24 items concerning teacher self-efficacy (six sub-domains), estimated on a 7-point Likert-type scale (1 = *not certain at all* and 7 = *absolutely certain*). Of the original items, we translated (first translated from English to Swedish by one author and then back translated from Swedish to English by another author, after which both English versions were compared) and modified 12 items to explicitly measure teaching efficacy beliefs in mathematics for three sub-domains:

² In Finland, approximately 5.5% (290 000) of the population speaks Swedish as their native language. This segment of the population is mostly people living in the west and southwest coastal areas. Parents can choose whether their child will start in a Swedish- or Finnish-speaking school and the school systems are equal. About 6.2% of an age group go to a Swedish-speaking school, and this number has increased over the last few years. Few universities offer all educational programs in Swedish and others provide a selection of programs.

instruction (questions on how certain they are about answering student questions such that they understand mathematical problems), *adapt instruction to individual needs* (e.g., how certain they are about organising classwork such that both low and high achievers can work with (math) tasks at their own level); and *motivate* students (e.g., how certain they are to get students to do their best, even with more challenging (math) tasks). We excluded measures for classroom management and relationships with parents, as they were not of interest to the present study.

To measure *subject knowledge* in mathematics, we used KTLT, a Finnish standardised assessment test (Finnish-Swedish version; Räsänen, Linnanmäki, Korhonen, Kronberg & Uppgård, 2013). KTLT is based on the basic mathematical skills for grades 7–9 (13–15 years). There are different tests for different grades, and in this study we used the digital version meant for grade 9, which is the last year of compulsory school in Finland. The test consists of adaptive multiple-choice questions and open questions on basic arithmetic, applied problem solving, and algebra. Since there is a narrow selection of mathematics assessments in Swedish for adults, KTLT was chosen to measure the participants' mathematical level.

Data Analysis

The analyses were conducted in several stages using the statistical software package Mplus 7.1 (Muthén & Muthén, 1998–2013). To assess the quality and dimensionality of the measurements, internal consistency analyses (Cronbach's alpha) and confirmatory factor analyses (CFAs) were conducted. To assess the model fit in the CFAs, we followed Marsh, Hau, and Wen's (2004) recommended comparative fit index (CFI) of about .90 and 0.6 for the root mean square of error approximation (RMSEA). The maximum likelihood parameter estimates with robust standard errors were used in the CFAs and the path models. Concerning dimensionality, we were interested if the a priori three-factor conceptualization of teacher efficacy beliefs in the NTSES fitted the data better than an overall teacher efficacy factor. The

chi-square difference test with the Satorra – Bentler scaled chi-square was used to compare these competing models. The three-factor model fits the data better if the decrease in chi-square is significant compared to the one-factor model. To investigate the effects of pre-service teachers' individual interest and subject knowledge in mathematics on efficacy beliefs, we specified a path model in which efficacy beliefs were regressed on interest and subject knowledge. Owing to the small sample size, we used composite scores instead of latent variables in our path model. We also investigated if the number of study years is related to the outcome variables. The results indicated it was not and therefore this variable was not included as a covariate in the main analyses.

Results

Construct Validity, Internal Consistency, and Descriptive Statistics

We initiated the modelling with CFAs to investigate the construct validity of the interest and teacher efficacy measures. For the NTSES, the CFAs indicated that the a priori theoretical three-factor model, consisting of *instruction*, *adapt instruction to individual needs*, and *motivate students* ($\chi^2(51) = 65.46, p = .08, CFI = 0.97, RMSEA = 0.07$), fit the data better than a one-factor model, ($\chi^2(54) = 88.58, p < .001, CFI = 0.93, RMSEA = 0.12; \Delta\chi^2(3) = 20.394, p < .001$). For the individual interest scale, the CFA indicates that a one-factor model fits the data quite well ($\chi^2(57) = 17.92, p = .07, CFI = 0.98, RMSEA = 0.10$). The internal consistency of all the measures was good (Table 1).

The average mathematical level of special education pre-service teachers was $M = 112$ and $SD = 14$ and can be compared to the normative (IRT scale) for a grade 9 student ($M = 100, SD = 15$) (Räsänen et al., 2013). Correlations, means, standard deviations, and min-max for all variables are shown in Table 1.

[Insert Table 1 here]

Predicting Efficacy Beliefs with Individual Interest and Subject Knowledge

Next, the three teacher efficacy belief subscales were regressed on individual interest in mathematics (INTE) and subject knowledge (KTLT). In this model, INTE had a positive effect on all three teacher efficacy beliefs subscales (*instruction* (INSTR): $\beta = 0.581$, $z = 3.947$, $p < .001$; *adapt instructions to individual needs* (NEEDS): $\beta = 0.442$, $z = 2.281$, $p < .001$; *motivate students* (MOT): $\beta = 0.401$, $z = 2.189$, and $p < .001$), whereas KTLT did not ($\beta = -0.09$, $z = -0.515$, $p = 0.607$; $\beta = -0.174$, $z = -0.792$, $p = 0.428$; $\beta = -0.09$, $z = -0.482$, $p = 0.630$, respectively). This model explained 26.8% of the variance in INSTR, 11.1% of the variance in NEEDS, and 11.6% of the variance in MOT.

As per the preliminary correlations between the measures and prior research (Enochs et al., 2000; Gresham, 2008; Newton et al., 2012; Swars, 2005), we hypothesised that KTLT might have an indirect effect (via INTE) on the subscale INSTR. To investigate this option, a mediation model was tested on the data using bootstrapping and the ‘model indirect’ command in Mplus. We calculated the bootstrap confidence intervals (95%) using 1,000 bootstrap draws for the indirect effects (Preacher & Hayes, 2008; Shrout & Bolger, 2002). The indirect effect is statistically significant if the confidence interval excludes zero. As per our expectations, the indirect effect from KTLT via INTE was significant ($\beta = .42$, 95% CI [.22, .62]) (Figure 1), indicating that individual interest fully mediates the relationship between subject knowledge and teacher efficacy beliefs concerning instruction in mathematics.

[Insert Figure 1 here]

Comparing Mean Levels of Teacher Efficacy Beliefs

To answer research question three, a repeated measures ANOVA was performed to compare the mean levels of the three teacher efficacy subscales. The analysis revealed a

moderate main effect on the teacher efficacy subscales ($F(2,110) = 7.4, p = 0.001, \eta_p^2 = .012$).

Post-hoc tests showed that teacher efficacy beliefs for instruction and adapting instructions to individual needs had higher mean scores than motivating students (Table 1). However, the small overall effect size indicates that the observed differences are small in magnitude.

Discussion

This study aimed to investigate the interrelations among subject knowledge, individual interest, and teacher efficacy beliefs in mathematics among special education, pre-service teachers. The findings indicate that individual interest plays an important role in all three sub-domains of pre-service teachers' efficacy beliefs in mathematics, while subject knowledge must be coupled with individual interest to have an effect, despite which its influence is restricted to efficacy beliefs concerning instruction in mathematics. In addition, pre-service teachers showed significantly less teaching efficacy in mathematics in terms of motivating students compared to instruction and adapting instructions to students' individual needs.

Individual interest in mathematics was found to be a strong predictor of teaching efficacy beliefs in mathematics. In addition, the findings revealed a relationship (albeit indirect) between subject knowledge and teacher efficacy beliefs on the basis of instruction in mathematics. However, we found no significant relationship between subject knowledge and teacher efficacy beliefs in motivating students or adapting instructions to individual needs. In other words, subject knowledge is of importance for efficacy beliefs only if the teacher also has an interest in mathematics. This is partly in line with the finding of Schiefele, Streblow, and Retelsdorf (2013), who also found a significant relationship for both teachers' subject interest and didactic interest in teachers' self-efficacy. Tella (2008), on the other hand, found no correlation between teacher efficacy beliefs and interest in teaching mathematics, even when both factors affected student achievement. Our results also partly conflict with those of

earlier research, in which mathematics performance was found to have a significant relation with teacher efficacy beliefs (Austin, 2013; Bates et al., 2011; Newton et al., 2012; Swackhamer et al., 2009). The variation in results can be attributed to the use of different scales (e.g. different sub-domains or models) or the differences in context or teacher groups (Berg & Smith, 2016). However, as to the best of our knowledge, no other study has used interest and subject knowledge to predict teacher efficacy. In this study, individual interest was found to have a larger effect on teacher efficacy beliefs than subject knowledge, and the difference in results can be attributed to the use of interest and subject knowledge in the same model. As self-efficacy is developed through experiences, a reason for the lack of a significant relationship between subject knowledge and adapting instructions to individual needs and motivating students struggling in mathematics could be pre-service teachers (with low subject knowledge) overestimating their teacher efficacy, which generally is a result of insufficient experience in teaching mathematics in the field (Bates et al, 2011; Haverback & Parault, 2008). Foss and Kleinsasser (1996) found that teacher experience negatively affected teachers' self-efficacy in teaching mathematics, where pre-service teachers reported higher teacher efficacy than in-service ones. It can also be a consequence of pre-teachers' vicarious experience (Bandura, 1994) when they, for example, watch other pre-service or in-service teachers successfully teaching mathematics to low-achieving students; this allows them the perception of being able to cope with similar situations. Another possible reason is that pre-service teachers with weaker subject knowledge perceive that they are able to teach mathematics to diverse learners, owing to their own struggle with mathematics in school.

In this study, teacher efficacy beliefs were measured for three sub-domains and the results indicated that pre-service teachers had significantly higher teacher efficacy beliefs for instruction (in general and for individual needs) than for student motivation. Given the results in the extant literature that students' performance is affected by teachers' efficacy beliefs

(Austin, 2013) and that low-performing students, in particular, can benefit from having teachers with high teacher efficacy beliefs (Edmonds & Spradlin, 2010), these findings are promising and suggest that special education pre-service teachers feel comfortable with their future work as instructors for students in need of support in mathematics. However, according to a report by OECD (2016), low-performing students have lower motivation in terms of mathematics compared to higher achieving ones. This reinforces the importance of teacher impact on student motivation for mathematics, and it is a field to focus on and develop in future teacher education.

This study reported a wide range on all variables (teacher efficacy beliefs, interest, and subject knowledge) from minimum to nearly maximum points. As a result, it is possible that pre-service teachers with almost no teacher efficacy (or interest) in teaching mathematics and with very low subject skills in mathematics may teach mathematics to low-achieving students in the future. Unfortunately, negative beliefs and low interest in mathematics are quite common among pre-service teachers and can even cause anxiety towards the subject (Boyd, 2014; Brusil & Paznokas, 2006; Faulkner & Cain, 2013; Gerretson, Alvare, & McHatton, 2009; Humphrey & Hourcade, 2010; Rosas & Campbell, 2010; Swars, Daane, & Giesen, 2007). For many pre-service students, negative beliefs originate from their own school experiences (primary and secondary level) with mathematics (Boyd, 2014; Uusimäki & Nason, 2006). To avoid such negative experiences, it is important to strengthen pre-service teachers' interest and efficacy beliefs in mathematics. Since interest develops through several phases and may need help to grow (Hidi & Renninger, 2006; Renninger, 2009; Renninger & Su, 2012), teacher education must account for strengthening pre-service teachers' interest in mathematics. Doing so warrants at least basics knowledge in the subject (Linnenbrink-Garcia et al., 2012), which means that pre-service teachers' mathematical level is also of importance.

Teachers working with low-achieving students can also benefit from having high self-beliefs, which help them maintain interest, motivation, and belief towards their own work (King-Sears & Baker, 2014). As teachers' efficacy beliefs predict competence in instructional practices, classroom management and student engagement, high teacher efficacy beliefs can serve as an advantage for low-achieving students (Edmonds & Spradlin, 2010; Woodcock & Reupert, 2016). In addition, Brownell and Pajares (1999) reported that teacher efficacy beliefs have a direct positive impact on teachers' perceived success in instructions for students needing support in general education classrooms.

In this study, pre-service teachers' subject knowledge in mathematics was about one standard deviation higher than that of an average student in grade 9. Several studies have discussed the importance of special education teachers' subject knowledge in mathematics, given its key role in student achievement, especially of those needing additional support (e.g. Flores, Patterson, Shippen, Hinton & Franklin, 2011; Griffin et al., 2009; Rosas & Campbell, 2010). Thus, in addition to strengthening special education pre-service teachers' subject knowledge in mathematics, teacher education should find ways to organise mathematics education to guarantee that every student (on various levels) has a teacher with high subject knowledge in mathematics. Studies have reported that an inclusive model, with support from a special resource or co-teacher, is an effective model to support students in mathematics, especially in secondary school (Hoover & Patton, 2008; Mageira, Smith, Zigmund, & Gebauer, 2005; Saloviita & Takala, 2010; Weiss & Lloyd, 2002). A combination of mathematics teachers' knowledge and special education teachers' specialised instruction of low-performing students seems to be a favourable educational setting (Mageira et al., 2005).

Despite its contribution, this study is subject to some limitations. First, the pre-service teachers participated in their spare time and the selection of pre-service teachers may thus be biased. Teachers who were genuinely not interested in mathematics or those feeling

uncomfortable to participate in a mathematical test may have decided to opt out of the study, although few pre-service teachers chose to do so. Second, our sample was too small to detect possible small effects in our analyses. Future studies with larger samples are warranted for more sophisticated analyses.

Conclusion

In sum, the present study contributes to the understanding of complex factors affecting teachers' efficacy beliefs by analysing interrelationships among efficacy beliefs, interest, and subject knowledge in mathematics. The findings highlight the importance of interest in mathematics for teacher efficacy beliefs. These findings can increase our understanding of how to support pre-service special education teachers' development of competencies and beliefs about themselves as teachers. Subject knowledge, nevertheless, remains important although it must be coupled with interest to have an effect on teachers' efficacy beliefs. Pre-service teachers' efficacy beliefs to motivate students seem to be lower than other domains of teacher efficacy. Thus, further studies should focus on how teacher education can develop pre-service teachers' interest in mathematics as well as methods to strengthen special education pre-service competence to motivate students. In addition, longitudinal studies of teacher efficacy beliefs would be of interest to broaden research in this field.

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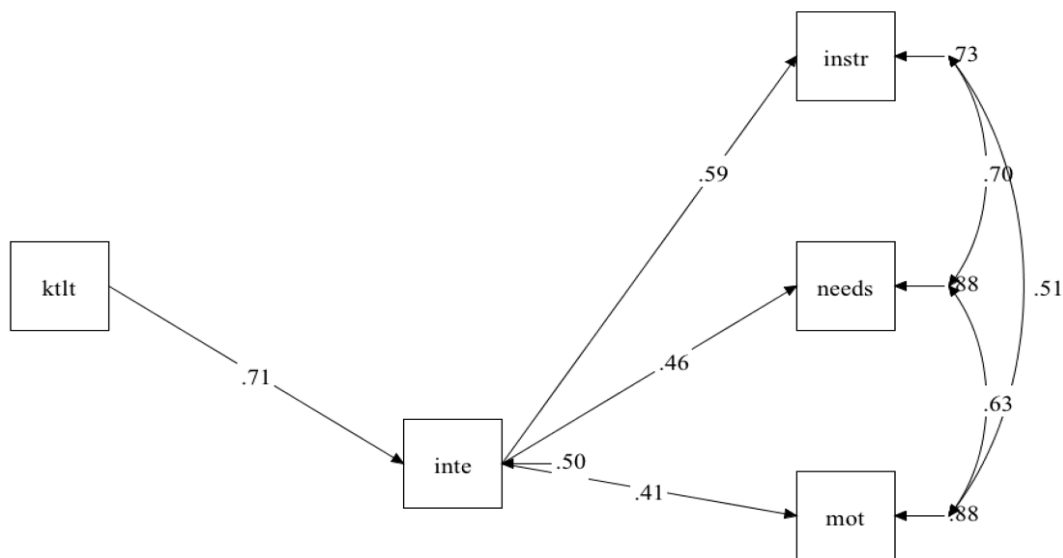


Figure 1. Predicting teachers' efficacy beliefs with individual interest and subject knowledge in mathematics. Note: All paths are significant ($p < .05$). KTLT = subject knowledge in mathematics; INTE = individual interest in mathematics; INSTR = general instruction; NEEDS = adapt instruction to individual needs; MOT = motivate students.

*Table 1**Correlations and descriptive statistics*

Variable	1.	2.	3.	4.	5.
1. Instruction	-	.804**	.694**	.341**	.514**
2. Adapt instructions to individual needs		-	.763**	.154	.312*
3. Motivate students			-	.208	.335*
4. Subject knowledge in mathematics				-	.743**
5. Individual interest in mathematics					-
<i>M</i>	18.7	19.0	17.7	112.2	23.7
<i>SD</i>	4.1	3.6	3.5	14.4	10.6
Min–Max	4-25	4-25	6-27	85-145	7-48
Cronbach's alpha	0.89	0.88	0.87		0.95

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level